Validation of cloud optical parameters from passive remote sensing in the arctic by using aircraft measurements

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Cloud Optical Parameters (COPs; e.g., cloud optical thickness, thermodynamic phase, and cloud effective radius) and surface albedo are the most important inputs for determining the shortwave Cloud Radiative Effect (CRE). In the Arctic, the COPs derived from passive remote sensing, such as from the Moderate Resolution Imaging Spectroradiometer (MODIS), are difficult to obtain with adequate accuracy, owing not only to insufficient knowledge about the snow/ice surface but also to the common occurrence of thin clouds. This study aims at evaluating the broadband and spectral irradiances calculated from MODIS-derived COPs in the Arctic with aircraft measurements collected during the Arctic Radiation-IceBridge Sea and Ice Experiment (ARISE) based in Fairbanks, Alaska. During ARISE, the Solar Spectral Flux Radiometer (SSFR) and the Broadband Radiometer system (BBR) provided upwelling and downwelling shortwave spectral and broadband irradiance, respectively. In the first step, the spectral snow surface albedo was derived from the collective irradiance measurements, accounting for partially snow-covered scenes by the snow fraction estimated from aircraft camera imagery. In the second step, we used a radiative transfer model (RTM) to calculate the upwelling and downwelling spectral irradiance at flight level, incorporating the MODIS-derived COPs and SSFR-derived spectral surface albedo for "pure snow" as inputs. The calculated irradiances were then compared with the measured broadband and spectral irradiance pixel by pixel for all suitable aircraft underpasses of the satellites.

We found that although MODIS provides reasonable COPs for thick clouds, it cannot detect optically thin clouds with cloud optical thickness less than around 7. Because thin clouds occur so frequently in the Arctic, undetected clouds may be the dominating error source of fluxes and CRE derived from passive imagery. Future work needs to focus on (a) obtaining systematic aircraft or surface-based observations of fluxes, surface albedo, and COPs and (b) on new methods to enable passive imagery based retrievals even for thin clouds. We will discuss possible avenues for both.

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